International Journal of Agricultural
Science and Research (IJASR)
ISSN(P): 2250–0057; ISSN(E): 2321–0087
Vol. 9, Issue 6 Dec 2019, 15–26

TRANS STELLAR
•Journal Publications •Research Consultancy

THRESHER RELATED ANTHROPOMETRIC PARAMETERS OF WOMEN AGRICULTURAL WORKERS FOR VIDARBHA REGION OF MAHARASHTRA (INDIA)

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ABSTRACT

Anthropometric parametric data are very useful in ergonomics where statistical data about the distribution of body dimensions related to varying population are used to optimize human–machine interaction. Agriculture is an important unorganized sector where women in rural India by active participation play a significant role in shaping the country's economy. In agriculture sector most of the activities women do are tedious, time consuming, and drudgery prone. Women's involvement is found in threshing which is one of the important post- harvest operation of grains out of various activities. For appropriate and efficient designing and design improvement of thresher anthropometric parameters of female agricultural workers is important. To check compatibility with thresher of women Agricultural workers for Vidarbha region of Maharashtra (INDIA) no information is available. Present study on Thresher Related Anthropometric parameters of women Agricultural workers were undertaken on 200 women agriculture workers in the age range of 20–50 years for Vidarbha region of Maharashtra (INDIA). A set of 16 anthropometric parameters which were found to be applicable in the design of thresher, were identified. The mean, standard deviation, range and percentile values (5^{th}, 95^{th}) of selected anthropometric parameters were tabulated. The mean of the anthropometric parameters were compared with those obtained for the women agricultural workers from other parts of the country. The data obtained were intended to be used for design or design modifications of thresher considering ergonomics with a view to reduce musculoskeletal disorders, drudgery and at the same time increase efficiency, safety and comfort on the part of workers. In conclusion, this study meets a very important need for anthropometric data considering key design requirements of thresher. Data were collected through systematic and scientific way for making it comprehensive and useful especially for women Agricultural workers for Vidarbha region of Maharashtra (INDIA).

KEYWORDS: Ergonomics, Anthropometry, Women Agriculture Workers & Thresher

Received: Sep 06, 2019; **Accepted:** Sep 26, 2019; **Published:** Oct 31, 2019; **Paper Id.:** IJASRDEC20193

Original Article

INTRODUCTION

Anthropometric parametric data are very useful in ergonomics where statistical data about the distribution of body dimensions related to varying population are used to optimize human–machine interaction and anthropometric database satisfy basic needs of designers. Agriculture, recognized as the most hazardous occupation, has been consistently shown that musculoskeletal disorders are the most common of all occupational injuries for farm workers. India as an agricultural based country and agriculture is a highly gender sensitive sector wherein large women workforce are engaged. Woman plays a significant and crucial role in agricultural workforce by doing most tedious

task in agriculture. It is a fact that the women of rural areas contribute to agricultural in various task including livestock production, horticulture, post-harvest operations, etc. In Maharashtra, agriculture takes care of about half of the population for its livelihood constituting the single largest provider of employment to the rural people of the state. Vidarbha is eastern region of Maharashtra. According to the survey done so far, it is vivid that less anthropometric database is available related to the agriculture women workforce, lesser in Maharashtra and almost negligible work is done considering women farm workers at Vidarbha level. There is a need to conduct study for agriculture women workers of vidarbha.

Threshing is a key part of agriculture that involves removing the seeds or grain from plants stalk. Thresher is a device that first separates the head of a stalk of grain from the straw and then further separates the kernel from the rest of the head. There are physical dangers involved in introducing machinery into a farming process. One of these is injury to hands and arms when feeding the stalks into the thresher. From the survey of accidents in Indian Agriculture, All India Coordinated Research Project on Ergonomics and Safety in Agriculture, of the total accidents reported during a period of one year, 30.5% accidents were due to farm machines, under the farm machinery category 14% due to threshers. Therefore, the equipment which needs immediate attention is threshers. Threshers were introduced during seventies in Indian agriculture. Due to various benefits of threshers like saving in time, cost and human energy, the farmers adopted it to a very large extent. Large number of thresher accidents and many workers lost their lives/limbs. So, safe feeding devices for power threshers were designed and included in BIS standards. In 1983, the Govt. of India enacted the “Dangerous Machines (Regulation) Act-1983" DMRA-1983 and made the safe feeding chutes/safe feeding system compulsory on power threshers.

Many agricultural projects aimed at men with the assumption that they will somehow automatically benefit women through ergonomical characteristics of women are different than men workers. “These tools or equipments will increase work load and occupational disorders in spite of decreasing, if not fit for the subject. Poor design and excessive use of hand tools are associated with increased incidence of both acute and sub acute cumulative trauma of hand wrist and fore arm” [1].

The book edited by Gite et al. [2] represents of “both male and female provide database from 12 states of India”. At present studies reported for collection of anthropometric data on Indian Agricultural workers of the country are Dewangan et. al. [3], Joshi et al. [4], Mohanty [5], Bini Sam [6,7], Borah Swapnil [8], Premkumari et al. [9].

Farm mechanization plays a significant role in increasing production and productivity of farm and farmers in the country with suitable farm machineries. The developed farm machinery is being used by the farmers, particularly men while women farmer are still in passive role in agriculture. Anthropometric database will help in designing/redesigning of Thresher. Looking at the scenario of Vidarbha region it is clear that no data is available for women workers.

The study aims at providing an anthropometric data of Vidarbha region of Maharashtra considering key design requirements related to anthropometric parameters of thresher.

MATERIAL AND METHODS

Selecting Study Sample: Methodology and Zone Distribution

This study is focusing on eastern region of the Indian state of Maharashtra known as Vidarbha. Vidarbha has 11 districts namely Amravati, Akola, Bhandara, Buldana, Chandrapur, Gadchiroli, Gondia, Nagpur, Wardha, Washim

and Yavatmal. The women considered in the present study were distributed in three different geographical zones likewise:

Western Vidarbha: Buldhana, Washim, Akola, Amravati

Eastern Vidarbha: Bhandara, Gadchiroli, Gondia, Chandrapur

Central Vidarbha: Nagpur, Wardha, Yavatmal

According to the 2011 census [10] of the government of India, Vidarbha has total population of 23,003,179. The number of subjects was estimated according to the Sampling Technique mentioned by Gite [2]. Generally, random sample shall be taken from a population for the sample to be representative. However, in a large-scale anthropometric survey, the ideal random sampling procedure is not feasible.

Sampling Technique

- Divide the country in different states and decide the sample size in proportion to agricultural workers population. State wise population may vary from 600 to 2000.
- Divide the state in agro-climatic zones and break the sample size in proportion to agricultural workers population. In each agro-climatic zone the sample size may vary between 200 and 500
- It would be preferable to collect data from each district. However, if there is homogeneity in the subjects, data collection points can be reduced. Efforts should be made to include most of the tribes/communities involved in agricultural occupations.

So, present survey was carried out for agro-climatic zone of Vidarbha region of the Indian state of Maharashtra with sample size of 200 by taking the samples from each district to make the sample representative. As per, Indian Standard code of practice for installation, operation and preventive maintenance of power threshers (IS9019-1979) clause No.9.8 – only skilled and trained workers should be employed for feeding the crop. Children below 16 years of age and elderly people above 50 years lacking physical stamina should be discouraged to work specially for feeding the crop. So, subjects from the age group 22–50 were selected for the study.

Data Collection Procedure

Considering requirement of Vidarbha Female Agricultural workers.

It includes five components.

- Identification of Anthropometric parameters useful in thresher design.
- Design and methodology for data collection.
- Collection of Data.
- Compilation of Data and Building up of data bank.
- Analysis and presentation of data for use by thresher machinery industry/research/other interested group.

Identification of Anthropometric Parameters useful in Thresher Design

The operation of detaching the grains from the ear head, cob or pod is called threshing. Threshing is a key part of agriculture

and thresher is a device that first separates the head of a stalk of grain from the straw, and then further separates the kernel from the rest of the head. During the last two decades in the country, power threshers have become quite popular. Power threshers are mainly classified according to crops being threshed as single crop and multi-crop. Since, the Indian farmers raise variety of crops as per the suitability of particular region, climate and soil conditions. Multi crop thresher is suitable to thresh all these crops for timelines of operation. The farmer is primarily interested in multi crop thresher, are commercially available and popular in the country. As discussed in introduction of this study, the equipment which needs immediate attention is threshers as per the survey of accidents and large number of thresher accidents and many workers lost their lives/limbs. One of these is injury to hands and arms when feeding the stalks into the thresher. After studying history, type, process, principle of threshing, main components, various functional components of threshing units and vast survey done in market for Vidarbha region and concluded with selection of multi crop thresher. Sixteen different anthropometric parameters were considered important for design of thresher requirement and Standard terminologies have been used as given in the Anthropometric source book (NASA,1978 a&b) [11–13].

Design and Methodology for Data Collection

Protocol followed in conducting anthropometric survey.

The subjects were briefed about the survey beforehand demonstrating the measurement protocol in order to ensure their full cooperation.

- Consent has been taken from each subject prior to study
- Care has been taken to select farm women who are healthy, non pregnant and free from any serious health hazards and similar physical and physiological parameters.
- All the dimensions were measured in a correct posture and in precise manner to ensure maximum accuracy.
- During the measurement due care taken to avoid any excessive compression of underlying tissues and to record the measurement correctly.
- All the subjects wear light clothing without foot wears.
- Standing surfaces (floors), platforms or sitting surfaces shall be flat, horizontal and not compressible.
- All the measurement was taken three times.
- Subjects from the age group 22–50 were selected for the study
- During this period mean dry bulb temperature, relative humidity, air velocity was noted.
- The selected subjects had previous experience of using thresher machines.
- Preferably Study time: 9:00am to 1:00 pm.
- Respondents were asked to work in a natural way. Care has been taken so that subjects feel relaxed and free while measurements were carried out.
- Prior to data collection subjects were informed about the objectives of the study and their role in the study.
- The Surveyor had sufficient knowledge of anatomical landmarks of the human body.

- All the vertical measurements were taken from right hand side.
- Subjects were selected according to the availability and willingness to participate without payment or any other reward.
- Noted the addiction habit of the subject i.e. tobacco chewing, pan chewing etc.
- Effort has been made to include most of the tribes/community involved in agricultural occupation.

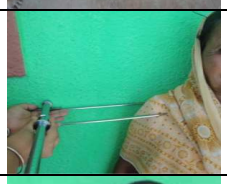
The methodology for the measurement was according to the literature from [14] [2]

Equipment Used

Anthropometer, an instrument to measure Anthropometric parameters was utilized which is suitable for measuring nearly any linear dimension of the human body. Digital Weighing Scale was used to measure body weight. A standard weighing scale (0–150 kg of least count 100 g, Calibrated against standard weights 10–100 kg). Anthropometer was calibrated before use and sensitivity was within the recommended limit. Specifications of anthropometer: Brand Name: ICS, Material Type: Brass+ SS. To measure dimensions of human parts, Antropometer length 0–210 cm for location of all height measurements of the whole body. Specifications of weighing Scale: Venus Abs-9999 Digital Weighing Scale (Black), Measures in: kg, Material: Plastic, Maximum Weighing Capacity: 150 kg.

Table 1: Brief Description of Measurement and its Application for Thresher Design Guideline with Illustrative Photograph

Photograph	Description of Parameter	Application for Thresher Design/Modification Guideline
	Weight: Body weight measured on a calibrated weighing scale	It is a general body description for checking strength of standing platform 95th percentile value of user population to be considered
	Stature: The vertical distance from the standing surface to the vertex of the head when the subject stands erect and looks straight forward	Vertical clearance from ground, workplace design. 95th percentile value of user population to be considered
	Eye height: The vertical distance from the standing surface to the external canthus of the eye when the subject stands erect and looks straight forward	Work place layout design. Design of feeding Chute/hopper of thresher.5th percentile value of user population to be considered
	Acromial height: The vertical distance from the standing surface to the acromion. The subject stands erect and looks straight forward	Work place layout, body linkages, for deciding feeding chute height, for lifting, for use in force. For design purpose, 5th percentile value of user population is to be considered
	Elbow height: The vertical distance from the standing surface to the top of the radiale when the subject stands erect and looks straight forward	General body description, work place layout, body linkages. For design purpose 5th percentile value of the user population to be considered
	Olecranon height: The vertical distance from the standing surface to the height of the undersurface of the elbow, measured with the arm flexed 90 degree and the upper arm vertical. The subject stands erect and	Work-place layout, body linkages, platform height for work to be done in standing posture. 5th percentile value of user population is to be considered

	looks straight forward	
	Illiocrystale height: The vertical distance from the standing surface to the top of the ilium in the mid axilary plane. The subject stands erect and looks straight forward. This is also known as waist height	Body linkages, material handling height recommendation. For design purpose 5^{th} percentile value of the user population to be considered
	Knee height: The vertical distance from the standing surface to the mid point of knee cap. The surface stands erect and looks straight forward	Body linkages, work place design, height of platform for thresher design. For design purpose 5^{th} percentile value of the user population to be considered
	Span: the distance between the tips of right and left middle finger when the subject arms maximally extended laterally	Work place design, for material handling. for reach purpose, 5^{th} percentile value of the user population to be considered
	Arm reach from the wall: The distance from the wall to the tip of the middle finger measured with subject shoulder against the wall, hand and arm extended forward	Body linkages, workplace layout, and clearance. For reach purpose, 5^{th} percentile value of the user population to be considered. for clearance purpose, 95^{th} percentile value of the user population to be considered
	Shoulder grip length: The horizontal distance from a pointer held in the subjects fist to a wall against which he/she stands, measured with the arms extended horizontally	Body linkages, workplace layout, reach envelops. For reach purpose, 5^{th} percentile value of the user population to be considered. for clearance purpose, 95^{th} percentile value of the user population to be considered
	Wall to acromian distance: The horizontal perpendicular distance from the wall to acromion measured when the subject stands erect against a wall	Body linkages, workplace layout, reach envelops. Depending upon design requirement, the percentile value of the user population to be considered
	Abdominal extension of wall: The vertical distance from the most laterally protruding point of the abdomen to a wall against which the subject stands erect with minimal wall-buttock contact and looking straight forward	Access, personal protective clothing design. for design purpose, 95^{th} percentile value of the user population to be considered
	Bideltoid breadth: The horizontal distance across the maximum lateral protrusion of the right and left detoid muscles. The subject stands erect and looks straight forward	Work place layout, body linkages, access opening. For design purpose, 95^{th} percentile value of the user population to be considered
	Caranoid Fossa to hand length: The distance from the tip of the middle finger to the coronoid fossa with arms bend at 90 degree with the upper arm	Thresher feeding chute design, chaff cutter feeding chute design. For reach purpose, 5^{th} percentile value of the user population to be considered. for clearance purpose, 95^{th} percentile value of the user population to be considered

	Forearm length: the distance from the tip of the elbow to the top of the middle finger measured along the long axis of the arm	Feeding chutes, for reach purpose, 5th percentile value of the user population to be considered. For clearance purpose, 95th percentile value of the user population to be considered f threshers

RESULTS AND DISCUSSIONS

During threshing operation, a worker lifts the crop material and inserts it in the feeding chute. The feeding chute should be at waist level (illocrystale height) however, above this height causes circulatory stress and undue early fatigue in the hand arm system. But due to construction and functional problems, it is not possible to keep the thresher feeding chute at such a low height. Therefore, a suitable standing platform should be provided in the thresher for operator to feed the crop in standing posture without bending [15]

Since natural postures do not involve static effort and natural movements are a necessary part of efficient work, it is also essential that work place should be suited to the body size of the operator. As feeding of crop to thresher is done by female workers also so while deciding the height of feeding chute/hopper, data of female workers are to be considered. To have minimum discomfort during feeding, it is necessary that the height of the feeding chute should be lower than the 5th percentile value of acromial height. Also to avoid the bending posture during feeding, the height should be more than the 95th percentile illocrystale height. For setting the higher limit the data of female workers will be considered whereas for setting the lower limit, the data for male workers has to be considered. If due to some machine design considerations, it may be possible to have this chute/hopper height, then a stable platform may be provided in such a way that the feeding chute/hopper height from platform level meets this requirement. As it is a matter of safety, the length of chute is to be decided considering arm reach from the wall. The length of top cover is to be decided on the basis of the forearm hand length [2].

Based on literature, field observation and survey 16 Anthropometric parameters were considered important for designing/modification of thresher and ergonomically designed work place layout for thresher–women worker as human–machine system. Anthropometric parameters selected are Weight, Eye height, Stature, Acromial height, Elbow height, Olecranon height, Illiocrystale height, Knee height, Span, Arm reach from the wall, Shoulder grip length, Wall to acromian distance, Abdominal extension of wall, Caranoid Fossa to hand length, Forearm length, Bideltoid breadth. It is widely agreed that 5th, 50th or 95th percentile values are more logically considered in design. Whereas, designer has to decide the percentile value as per the requirements. It is desirable to use boundary percentile values (5th or 95th) or the mean value for design purpose depending upon the dimensional element so that target user group will not get affected.

Table 2: The Data Compiled of Vidarbha Region

Dimensions	Mean	S.D.	Range	5th Percentile	95th Percentile
Weight-kg	47	10	29–82	30	63
Stature	1475	80	1357–1671	1344	1607
Eye height	1359	81	1245–1592	1226	1492
Acromial height	1230	74	1062–1415	1108	1352
Elbow height	949	61	825–1236	848	1050
Olecranon height	923	58	809–1197	828	1018
Illiocrystale height	880	58	771–1130	785	975
Knee height	416	44	324–515	344	489
Span	1498	98	1233–1738	1337	1658
Arm reach from the wall	772	70	665–892	656	888

Shoulder grip length	634	71	510–797	517	752
Wall to acromian distance	95	13	62–119	73	117
Abdominal extension of wall	207	56	132–342	116	299
Caranoid Fossa to hand length	351	34	282–489	296	406
Forearm length	412	38	314–501	350	474
Bideltoid bredth	347	44	272–468	275	420

The data compiled from three different geographical zones of the region, Western Vidarbha: Buldhana, Washim, Akola, Amravati, Eastern Vidarbha: Bhandara, Gadchiroli, Gondia, Chandrapur and Central Vidarbha: Nagpur, Wardha, Yavatmal. Table 2, the data includes mean, standard deviation, range, 5th and 95th percentile values (5th percentile value = Mean − 1.64 × Standard deviation and 95th percentile value = Mean + 1.64 × Standard deviation). Span in the range of 1233mm–1738mm to be considered for crop handling activity to avoid musculoskeletal problems occurred due to frequent twisting of trunk. As well 5th percentile value of Shoulder grip length – 517 mm. Wall to acromian distance – 73 mm, Abdominal extension of wall – 116 mm, Caranoid Fossa to hand length – 296 mm, Bideltoid breadth – 275 mm are important for proper workplace layout. The length of chute is to be decided considering arm reach from the wall. The length of top cover is to be decided on the basis of the forearm hand length

Results presented in the **Table 3** shows the mean values of 16 anthropometric parameters earlier surveys within the country. It can be observed from the table that women agricultural workers from Jammu & Kashmir and Punjab are more in weights, Meghalaya women agricultural workers are tallest and west Bengal women workers are less in stature. It can be interpreted that there is significant differences within population. And comparison among the region showed that significant differences in parameters were found. As there is variation among anthropometric parameters it is not practically feasible to design the equipment/workplaces so as to suit all users.

Table 3: Region-Wise Comparison between Mean Values of Female Anhtopometric Parametric Data for Thresher Design/Modifications

Dimensions	Maharashtra	Arunachal Pradesh	Gujarat	Jammu & Kashmir	Madhya Pradesh	Meghalaya	Mizoram	Orissa	Punjab	Tamil Nadu	Uttar Pradesh	West Bengal
Weight-kg	44.1	47.9	48.8	52.4	45.9	47.4	48.4	44	57.5	47.2	45.1	42.8
Stature	1504	1525	1521	1538	1538	1507	1552	1516	1516	1508	1508	1499
Eye height	1397	1410	1414	1427	1432	1392	1435	1403	1410	1386	1406	1385
Acromial height	1256	1265	1275	1279	1281	1242	1290	1250	1262	1258	1259	1243
Elbow height	953	957	955	983	973	960	976	960	944	966	948	939
Olecranon height	927	929	931	964	949	937	967	935	935	934	921	921
Illiocrystale height	884	892	898	928	924	894	903	882	895	900	891	894
Knee height	441	408	456	461	440	430	419	437	438	442	449	413
Span	1542	1535	1565	1572	1572	1532	1529	1583	1577	1532	1572	1532
Arm reach from the wall	775	731	777	780	775	768	731	760	775	794	777	779
Shoulder grip length	676	672	692	686	670	667	655	630	705	619	698	680
Wall to acromian distance	97	118	94	101	96	105	116	76	150	107	101	92
Abdominal extension of wall	209	212	220	238	226	185	208	209	213	196	217	213
Bideltoid bredth	360	362	400	404	383	375	376	351	374	361	359	357
Caranoid Fossa to hand length	356	398	405	386	393	367	364	393	399	387	398	379
Forearm length	427	407	416	417	430	395	407	419	435	420	407	401

CONCLUSIONS

Due to mismatch between size of equipment or work place and anthropometric parameters compilation of Anthropometric data for the design of machinery to prevent occupational injuries, occupational health problems, improved working condition, to minimize ergonomic problems and musculoskeletal disorders is much needed. This useful ergonomic data can be served as ready reference work place layout design solution for thresher considering women as a target group. The present study shows that it is essential to study anthropometric parameters for women workers and due attention should be given to while designing any agricultural equipment keeping in mind anthropometric data of women workers. To make the equipment women friendly and safe for operation, anthropometric have the greatest importance as proper matching of equipment with human capabilities is necessary for safety and optimum performance. Musculoskeletal disorders are major problems in agriculture.

There are significant differences among genders within population. Comparison among the region showed that significant differences in parameters were found.

The developed farm equipment is being used by the men farmers particularly men while women farmer are still not considered. This would have advantage of producing ergonomic farm equipment by encouraging women. In India attempts are made to generate region specific anthropometric data, but are limited to very few regions. There is a need to go for extensive surveys to generate region specific database for safe and efficient design/modifications of agricultural machineries.

Looking at the scenario of Vidarbha region it is clear that no consideration is given to the compilation of anthropometric database. Hence, this study is an attempt to overpass that gap which has been a kind of ignored till date for the betterment and speedy growth in agriculture field for Vidarbha region of Maharashtra (INDIA).

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